THORPEX

A Global Atmospheric Research Programme

International Science Plan

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Mission Statement - THORPEX: **a Global Atmospheric Research Programme** is an international research programme to accelerate improvements in the accuracy of 1 to 14-day weather forecasts for the benefit of society and the economy. The programme builds upon ongoing advances within the research and operational-forecasting communities. It will make progress by enhancing international collaboration between these communities and with users of forecast products.

Executive Summary

The success of numerical weather prediction represents one of the most significant scientific, technological and societal achievements of the 20th century. Despite the notable increase in forecast skill over the past quarter century, there is a necessity for further improvements, particularly, in the prediction of high-impact weather and in the use of weather information. High-impact weather forecasts are defined by their effect on society and the economy. They are typically associated with the forecasting of cyclones of arctic, extratropical and tropical origin that contain significant embedded mesoscale weather, such as localized flooding by convective and orographic precipitation; blizzard snows; destructive surface winds; dust-storms. They also encompass meteorological conditions affecting air quality, periods of anomalous high/low temperature and drought, and non-extreme weather with high-societal impact. Improving the skill of high-impact weather forecasts is one of the great scientific and societal challenges of the 21st century. THORPEX is a response to this challenge.

Emerging developments in atmospheric science and technology provide the opportunity for dramatic improvements in weather forecasts, and in their use and value to society. These developments include: i) advances in the knowledge of the theoretical and practical limitations of atmospheric predictability, including the influence inter-annual, and intra-seasonal climate variability has on weather forecast skill; ii) expanding observations of the Earth System with satellite, airborne, marine and land-based observing technologies; iii) weather forecast systems capable of assimilating observations from the above diverse technologies; iv) advanced forecast models aided by improvements in numerical techniques, explicit and parameterised representations of physical processes, and exponential increases in

the speed and memory of supercomputers; v) innovative approaches to the design and implementation of forecast systems that optimise the societal and economic utilisation of weather information. In the same way that the atmosphere encompasses the globe, the expertise to exploit and further these advances resides across many nations and international organizations.

THORPEX establishes a contemporary organisational framework to address global weather research and forecast problems, whose solutions require international and academic-operational collaboration. This will include engagement with other international programmes within the World Meteorological Organisation (WMO), the International Council of Scientific Unions (ICSU) and the Intergovernmental Commission for Oceanography (IOC). In this regard, THORPEX aspires to be the second Global Atmospheric Research Programme (GARP); building on the accomplishments of the First GARP Global Experiment (FGGY).

THORPEX is developed and implemented as a part of the WMO World Weather Research Programme (WWRP). The international co-ordination for THORPEX has been established under the auspices of the WMO Commission on Atmospheric Sciences (CAS) through its Science Steering Committee for the WWRP, and joint CAS/JSC Working Group on Numerical Experimentation (WGNE). The THORPEX International Science Steering Committee (ISSC) establishes the core research objectives with recommendations from the THORPEX International Core Steering Committee (ICSC) whose members are nominated by Permanent representatives of countries with the WMO. Research objectives are developed under four Sub-programmes: *Predictability and Dynamical Processes*; *Observing Systems*; *Data Assimilation and Observing-Strategies*; *Societal and Economic Impacts*. These Sub-programmes have the responsibility to coordinate the research activities envisaged in the THORPEX International Science Plan and THORPEX Research Implementation Plans, and will collaborate with other international programmes when relevant expertise is required. Nations and consortia of nations have established Regional Committees that define regional priorities for participation in THORPEX within the framework of the THORPEX International Science and Implementation Plans.

The core research objectives of THORPEX are to:

- Advance knowledge of global-to-regional influences on the initiation, evolution, and predictability of high-impact weather. This will include research into: i) the degree to which predictive skill is limited by observations, data assimilation, model uncertainty, or ensemble prediction system design at various forecast lead-times; ii) the role of extratropical cyclogenesis, large-scale topography, continent/ocean interfaces, and organised tropical convective flare-ups in the excitation of Rossby wave-trains and the consequent initiation of high-impact weather; iii) the dependence of predictive skill on inter-annual and intra-seasonal climate variability, e.g., El Nino Southern Oscillation (ENSO); Pacific North-Atlantic oscillation (PNA); North-Atlantic Oscillation (NAO); monsoon circulations.

- Contribute to the design and demonstration of *interactive forecast systems* that allow information to flow interactively between forecast users, numerical forecast models, data-assimilation systems and observations. Interactive forecast systems include the new concept of targeted observations, referred to as *targeting*. Targeting incorporates dynamical information from the numerical forecast model itself to identify when,

where and what types of observations would provide the greatest improvement to specific weather forecasts.

- Perform THORPEX Observing-System Tests (TOSTs) and Regional field Campaigns (TRCs). TOSTs will: i) test and evaluate experimental remote-sensing and *in-situ* observing systems, and when feasible, demonstrate their impact on weather forecasts; ii) explore innovative uses of operational observing systems. TRCs will be quasi-operational forecast demonstrations that will contribute to the design, testing and evaluation of all components of interactive forecast systems. They will be organised and coordinated by regional consortia of nations under their respective THORPEX Regional Committees (European, Asian, North-American, and Southern Hemispheric) TRCs will address regional high-impact weather events, e.g., arctic storms and cold-air outbreaks; cool-season extratropical cyclones over Europe and North America; warm-season heavy precipitation over Asia; organized equatorial convection flare-ups; tropical-to-extratropical cyclone transformations.

- Collaborate with numerical forecast centres in the development of advanced data-assimilation and forecast-model systems. This research will include: i) improving the assimilation of existing and experimental observations, including observations of physical processes and atmospheric composition; ii) developing adaptive data-assimilation and targeted-observing strategies; iii) incorporating model uncertainty into data-assimilation systems and in the design of ensembles.

- Develop and apply new methods to assess: i) the societal and economic value of improved weather forecast skill; ii) ways to make forecast systems more responsive to user needs; iii) the design of and training in the use of user-specific forecast products. This research will identify and assess societal/economic benefits and costs of THORPEX recommendations for implementing interactive forecast systems and improvements in the global observing system.

- Demonstrate the full potential of THORPEX research results for improving operational forecasts of high-impact weather on time-scales out to two weeks. This demonstration includes the **THORPEX Global Prediction Campaign,** which will: i) deploy the full suite of experimental and operational observing systems over the globe for a season to one year; ii) establish the utility of interactive forecast systems to provide improved weather forecasts and user products; iii) provide guidance, through the WMO/WWW, to agencies responsible for optimising the design and implementation of the fixed and adaptive components of the existing regional and global observing systems; iv) coordinate the transfer and application of THORPEX research to developing countries.

THORPEX is unique, in that:

- It establishes a contemporary organisational framework to address today's global weather research and forecast problems, whose solutions require both international and academic-operational collaboration. Its research domain spans global-to-regional influences on the prediction of high-impact weather. It addresses those mesoscale weather systems that form in response to the larger-scales and not those arising from purely local influences.

- It has at its heart a new paradigm in which weather forecasting is an *interactive* system with information flowing between forecast users, forecast models, data assimilation and the observing system.

- It will conduct regional and global campaigns as demonstrations and assessments of new observing technologies and interactive forecast systems. Thereby, THORPEX will provide guidance to WWW and international operational forecast centres on improvements to forecast systems, and to the relevant bodies, such as the WMO Commission for Basic Services CBS/OPAG, concerning optimisation of global and regional observing-systems.

- It addresses the influence of intra-seasonal time scales on week-two forecasts, and therefore aspires to bridge the "middle ground" between medium-range weather forecasting and climate prediction. This provides a link with other programmes addressing the improvement of global climate-change prediction systems.